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SOME SUBORDINATE RIDGES OF PENNSYLVANIA

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The topography of the folded mountain district of Pennsylvania consists of the narrow valleys and long, even-crested ridges cut by occasional water gaps and wind gaps which are familiar to the geologist and geographer the world over. For nearly a third of a century, since the publication of the epoch-making essay by Davis,[1] this region has been classic for the study of the peneplain. The tops of the even-crested ridges are said to represent the remnants of a surface which has been variously named the Cretaceous baselevel lowland,[2] the Schooley peneplain,[3] and the Kittatinny peneplain.[4] With the precise dates of formation of this supposed peneplain and the valley lowlands, generally called the Harrisburg peneplain,[5] we are not concerned here.

The formations sufficiently resistant to be ridge makers in Center County and neighboring counties are the Oneida and Medina sandstones of the earlier geologists, now known as the Oswego and Tuscarora respectively, separated stratigraphically by 490 to 850 feet[6] of the Juniata formation, consisting of soft red shales and sandstones. Of the two sandstones the Tuscarora is by far the more resistant to erosion, and accordingly in many instances on the limbs of close folds the topography finds expression in the close association of two ridges of different heights, usually with an intervening lowland on the soft Juniata formation. The discrepancy in height is not universal, as in several places in the Bellefonte quadrangle the Oswego ridges equal and even exceed in height those of the Tuscarora. It is the purpose of this article to show that these "subordinate ridges" as Willis[1] styles them, are more numerous than hitherto suspected, that their origin and existence have not been explained satisfactorily by physiographers, and that they constitute a menace to the validity of the Cretaceous peneplain theory.

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[1] W. M. Davis, "The Rivers and Valleys of Pennsylvania," *Nat. Geog. Mag.*, I, No. 3 (1889), pp. 183–253.

[2] *Ibid.*, p. 198.

[3] W. M. Davis and J. W. Wood, Jr., "The Geographic Development of Northern New Jersey," *Boston Soc. Nat. Hist., Proc.*, XXIV (1890), 377.

[4] Bailey Willis, "The Northern Appalachians," *The Physiography of the United States, Nat. Geog. Soc., Mon.*, I, No. 6 (1895), p. 189.

[5] M. R. Campbell, "Geographic Development of Northern Pennsylvania and Southern New York," *Geol. Soc. Am., Bull.*, XIV (August 5, 1903), 283–84.

[6] E. S. Moore, Unpublished data. Also Charles Butts, "Geologic Section of Blair and Huntingdon Counties, Central Pennsylvania," *Am. Jour. Sci.*, XLVI (September, 1918), 536.

The existence of subordinate ridges is noted by Willis[2] as follows:

> The simple monoclinal ridge which has been described is the typical but not the more common form of the Appalachian ranges. They become complex by association of parallel ridges. Thus on the inner slopes of Jacks and Stone mountains, about Kishicoquillas valley, there is a very marked bench or terrace, which appears as a broad step in the mountain slope. In other localities, when the outer edge of such a terrace is higher than its surface nearer the mountain, there are narrow ravines separating the terrace edge as a low ridge more or less distinct from the mountain itself. . . . . Elsewhere, again, ... the subordinate ridge may stand at a level equal with the continuous crest, and it then appears as a distinct monoclinal ridge.

The Stone Mountain referred to is the southernmost of the series of great consecutive ridges known as the Seven Mountains, which bound the Nittany valley on the south and is immediately north of the Kishicoquillas valley.

Davis[3] recognizes the existence of subordinate ridges:

> The beds of intermediate resistance, the Oriskany and Chemung sandstones, had not been worn down to baselevel at the close of the Tertiary cycle; they had indeed lost much of the height that they possessed at the close of the previous cycle, but they had not been reduced as low as the softer beds on either side. They were only reduced to ridges of moderate and unequal height over the general plain of the Siluro-Devonian low country, without great strength or relief but quite strong enough to call for obedience from the streams along side of them.

[1] Willis, *op. cit.*, p. 182.

[2] *Ibid.*, p. 182.

[3] W. M. Davis, "The Rivers and Valleys of Pennsylvania," *Nat. Geog. Mag.*, I, No. 3 (1889), pp. 243–44.

Again, in another article, he[1] says: "The weaker Siluro-Devonian beds are generally reduced to a lowland farming country, except where the Oriskany sandstone or a Chemung conglomerate of more resistance than the adjacent beds rises in ridges of moderate height. The hard Medina and Carboniferous sandstones hold their crests close to the Cretaceous peneplain."

Professor Davis assumes that the original height of the Oriskany and Chemung ridges equaled that of the Cretaceous peneplain surface but offers no confirmatory data. Apparently he does not distinguish clearly between the heights of the Oswego and Tuscarora ridges, but he may have this discordance in mind when stating[2] that the Medina crests accord with "geographic"rather than "geometric" exactness.

Years later Stose,[3] in comparing the high, even crest of Cross Mountain with the low, "comby" top of Cove Mountain in the Mercersburg-Chambersburg region in southern Pennsylvania, says: "It is apparent that Cove Mountain once stood at approximately this altitude, but has been lowered by the active erosion of the relatively narrow exposure of upturned rocks." Cross Mountain is supposed to be part of the old peneplain surface. Farther on in the same paper he says: "These two level tracts [referring to areas on South Mountain] are undoubtedly remnants of the old peneplain, preserved at the height of 2,000 feet. The monoclinal ridges along the front of the mountain, which once stood at this same altitude, have been reduced by erosion to 1,700 and 1,900 feet."[4] In these two quotations the height of a lower ridge is explained by reduction from the original peneplain.

Reverting to the Nittany valley and the Seven Mountains district, the following are altitudes[5] (obtained by barometer) on the Tuscarora summits south of Potters Mills and Boalsburg: Broad Mountain, 2,300 feet; Millikens Knob, 2,200 feet; a crest two miles south of Boalsburg, 2,300 feet; the mountain on road south of Pine Grove Mills, 2,010 feet; Roberts Knob, 2,410 feet; and Bear Meadows Mountain, 2,100 to 2,200 feet. The same map gives the following readings for the Oswego ridge summits: a ridge running from Bear Meadows north of Roberts Knob 26 miles northeast to Woodward, 1,700 feet average, attaining 1,800 feet in a few places; a corresponding ridge one mile southeast of the preceding on the other limb of the syncline, averages 1,800 feet for many miles; Tussey Knob, east of Boalsburg, rises to an altitude of 2,100 feet, rapidly sinking to the southwest to 1,600 and 1,700 feet average.

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[1] W. M. Davis, "The Geological Dates of Origin of Certain Topographic Forms on the Atlantic Slope of the United States," *Geol. Soc. Am., Bull.*, II (July 2, 1891), 572.

[2] *Ibid.*, p. 560.

[3] G. W. Stose, "Physiographic Studies in Southern Pennsylvania," *Jour. Geol.*, XII (1904), 476.

[4] *Ibid.*, p. 478.

[5] Charles E. Billin, "Map of Adjoining Portions of Huntingdon, Mifflin, Centre, and Union Counties," *Sec. Geol. Surv. Pa., Rept. of Progress S*, 1878.

Making allowance for possible slight inaccuracies in these map elevations a distinct discordance in height between the summits of the Oswego and Tuscarora ridges, in general, becomes manifest from the foregoing data. This discordance may be observed in the field, either from one of the higher and more commanding points on the Nittany valley lowland, or from some coign of vantage in the Seven Mountains, such as Roberts Knob. After six years' residence in the Nittany valley the writer is convinced that this difference in summit levels in the central Pennsylvania district is an important factor which cannot be passed over with the facility of some previous writers.

Space does not permit here the enumeration of instances of the difference in heights of adjacent mountain ridges in other states, but one example will show how universal the phenomenon is. In the Hancock, Maryland-West Virginia-Pennsylvania quadrangle the Cretaceous peneplain has been obliterated entirely in all probability, according to Stose,[1] but is preserved in the 2,000- to 2,200-foot summit of Cacapon Mountain in the Pawpaw quadrangle. This author[2] distinguishes between the Somerville (New Jersey peneplain) terrace[3] varying from 600 to 850 feet in elevation, the so-called Harrisburg peneplain level of 700 to 1,000 feet shown in many even-topped ridges and intermontane floor areas, a series of ridges averaging 1,200 feet in height, which he correlates with the Weverton, Maryland, peneplain,[1] and "remnants of intermediate erosion plains" from 1,550 to 1,700 feet in height.

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[1] G. W. Stose and C. K. Swartz, "Pawpaw-Hancock Folio, Md.-W. Va.-Pa.," *U.S. Geol. Surv.*, No. 179 (1912), pp. 19–20.

[2] *Ibid.*, p. 20.

[3] Davis and Wood, *op. cit.*, pp. 391–92.

Facts such as the foregoing give rise to doubts and queries which are of more than local significance. To admit the inadequacy of the Tertiary erosion to reduce completely some subordinate ridges to the valley-plain level seems to be overlooking the question of their origin as much as does the affirmation that the height of subordinate ridges represents a lowering and modification of an original, higher peneplain surface. As the geologist follows for miles two closely parallel ridges of even crests but of different heights, he is likely to think, as the writer does, that the origin of the two is the same, and that any explanation of the method of development of the one should be applicable to the other also. If the one represents a portion of the dissected and mutilated surface of an older peneplain, likewise, by the same reasoning, the other must represent something; but by no stretch of the imagination can some of the lower ridges of Pennsylvania be considered peneplain remnants.

Many years ago Hayes[2] expressed the belief that a lower ridge with even crest can be produced by reduction from a higher peneplain, as "corrasion is practically absent and only the forces of erosion are in play. Hence if the ridge was originally level it might remain so indefinitely or until it had been reduced far below the former surface of the baselevel plain."

Dr. T. C. Hopkins,[3] whose experience in central Pennsylvania entitles him to express an opinion, explains the development of these low ridges—the terraces of "terraced mountains"[4]—by reduction from the original peneplain; but he believes that the stratigraphic sequence of the rock series in the Nittany valley region must be taken into account in this connection. He lays emphasis upon the fact that the Tuscarora is underlain by the Juniata, a formation comparatively soft but not nearly as soft as the Reedsville (Utica), which consists entirely of very fissile shale. Thus the Oswego ridges would tend to become undermined faster than those of the Tuscarora, and this fact, coupled with the initial difference in weathering quality between the two sandstone formations, would result in a consistent difference in height of the ridge crests.

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[1] Arthur Keith, "Geology of the Catoctin Belt," *U.S. Geol. Surv.*, *Fourteenth Ann. Rept.*, 1892–93, Part 2, p. 388. Also W. B. Clark and E. B. Mathews, "The Physical Features of Maryland," *Md. Geol. Surv.*, VI (1906), 87, 88.

[2] C. W. Hayes, "Physiography of the Chattanooga District, in Tennessee, Georgia, and Alabama," *U.S. Geol. Surv.*, *Nineteenth Ann. Rept.*, 1897–98, Part 2, p. 27.

[3] Recent personal communication to the writer.

[4] T. C. Hopkins, *Elements of Physical Geography* (1908), pp. 338–39.

Explanations of the present height of the lower ridges, involving a process of reduction from former higher ridges, would seem risky in view of the lengths to which such arguments can be carried. Once admitting the possibility of the lower ridges maintaining their even crests and owing their ultimate origin to differential erosion, is it illogical to explain the even crests of the higher ridges by gradual erosional development contemporaneous with and subsequent to the long period of folding? In short, arguing from the topography of the ridges only, is it necessary to postulate a Cretaceous peneplain at all?

The writer has no alternative theory to suggest and no view to advocate, but merely raises the question, feeling that the Cretaceous peneplain theory does not explain adequately the existence of these minor ridges.

Of late the word "peneplain" has been used rather loosely and has been applied to conditions where direct proof is lacking. It is easy to conclude hastily that a ridge or series of ridges represents a peneplain, but much harder to prove such a statement. By no means is every ridge or upland remnant the remains of a peneplain, and a word of caution to workers in this field seems in order.

Professor A. M. Miller[1] may voice the feelings of others than himself in the following words:

> . . . . when one examines the literature of modern physiography and sees the readiness with which an "uplifted and dissected peneplain" is invoked

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[1] A. M. Miller, "Wind Gaps," *Science*, N.S., XLII, No. 1086 (October 22, 1915), p. 573.

to explain every even sky-line or approximate uniformity in heights of mountain summits, while every peculiarity in drainage is accounted for as an inheritance from a past cycle of erosion, overlooking in many cases a simpler explanation involving only "processes now in operation"; he wonders if there does not lurk therein somewhat of the old catastrophism.

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